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## HSI 2007: HSI in Human Spaceflight

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SF3/Susan D. Baggerman  
March 21, 2007

**HSI 2007 – Panel 3: Where HSI Meets the Road**

# *HSI in Human Spaceflight*

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# Overview

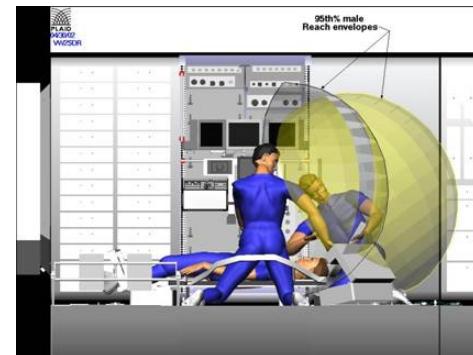
- Scope of HSI at NASA
- HSI Implementation in Human Spaceflight Programs
  - International Space Station (ISS)
    - Responsibilities
    - Lessons Learned
  - Constellation (Exploration) Program: Crew Exploration Vehicle (CEV)
    - Strategy/approach





### HSI – what it means to us...

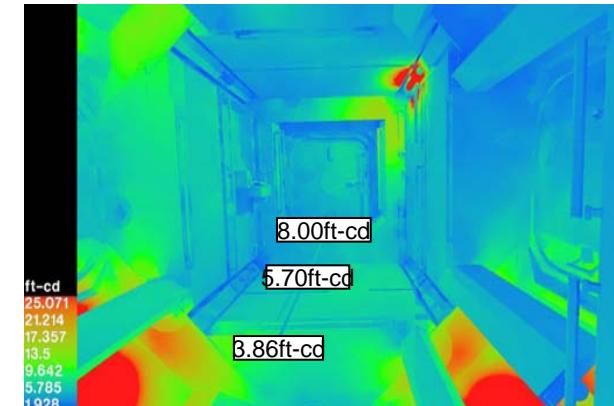
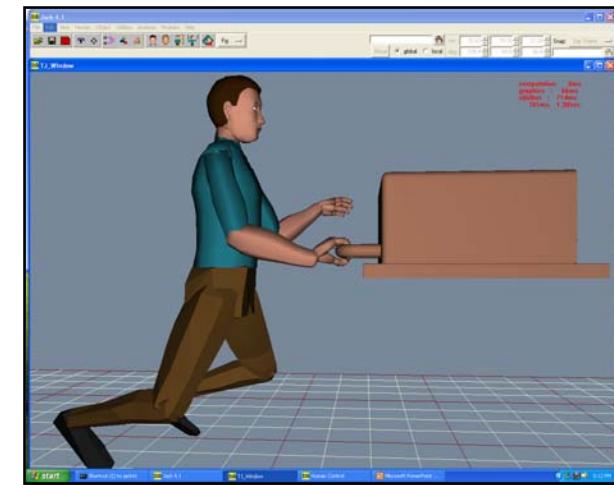
- The current scope of HSI at NASA is focused on the Human Engineering and Habitability domains of DoD's PRINT
  - Primary areas of emphasis are:
    - Anthropometry/biomechanics
    - Crew functions/habitability
    - Lighting/acoustics
    - Architecture
    - Maintenance
    - Crew hardware/equipment
    - Displays/controls
    - Labeling
- The definition of “HSI” is expanding at NASA with the Constellation Program through the Human-Systems Integration Requirements (HSIR) document
  - Includes sections on:
    - Natural/Induced Environments
    - Space Medicine
    - Ground Maintenance and Assembly

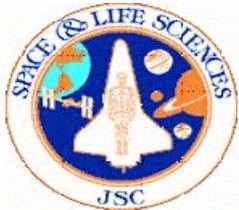




# HSI on the International Space Station (ISS)

- The HSI team for ISS is known as “Flight Crew Integration (FCI)”
  - FCI has been a recognized system in the ISS Program’s system engineering hierarchy since the late 1980s
- FCI Responsibilities
  - Requirements
    - Generation and flowdown
    - Verification
  - Design
    - Modules
    - Projects
    - Labeling
  - Operations
    - Sustaining engineering
    - Anomaly/issue resolution





### HSI in the Constellation Program

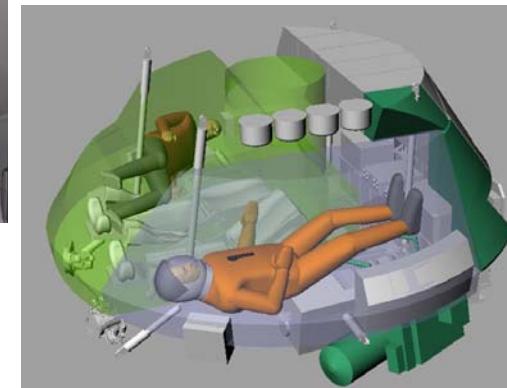
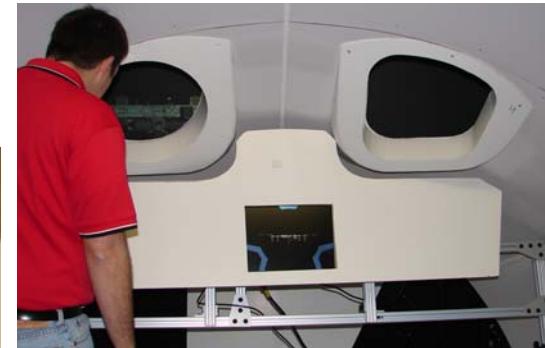
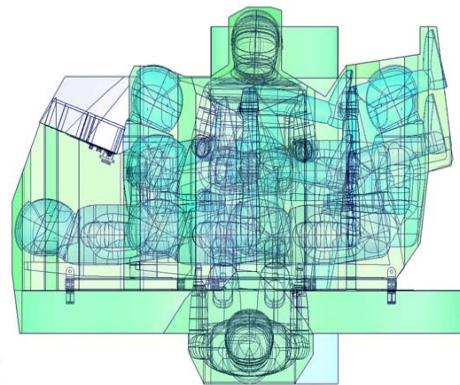
- HSI is being implemented at every level
  - Level 1 (NASA Headquarters):
    - Today: Human Rating Requirements (invokes inclusion of NASA-STD-3000)
    - Soon: Space Flight Human Systems Standards (invoked directly by NASA Health and Medical Policy Directive)
  - Level 2 (Program-Level):
    - Human Systems Integration Group (HSIG)
    - Human-Systems Integration Requirements (HSIR)
  - Level 3 (Project-Level):
    - Crew Exploration Vehicle (CEV) Human Engineering System
    - CEV Radiation System
    - CEV Crew Health Interfaces Systems
    - CEV Food Interfaces System
  - Level 4 (Prime Contractor-Level):
    - CEV: Lockheed-Martin Human Engineering Team, other technical HS teams (radiation, etc.)

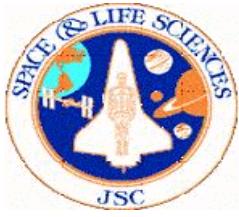




# HSI Team in the CEV Project Office:

- Responsibilities
  - Requirements
  - Design & Analysis
  - System Integration
  - Verification
  - Information Display & Design
  - Operational Integration





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### Back-up Charts



### Requirements

- FCI is uniquely responsible for ISS Program Office human factors (SSP 50005) requirements
- Work with module and hardware developers to provide human factors integration, including item-specific functional requirements for crew interfaces
- Analyze and evaluate compliance of designs with human factors requirements and principles
- When necessary, evaluate and process waivers and Interpretation Memos to SSP 50005 requirements

- Example – Handle clearance for Water Processor Assembly

- Requirement:

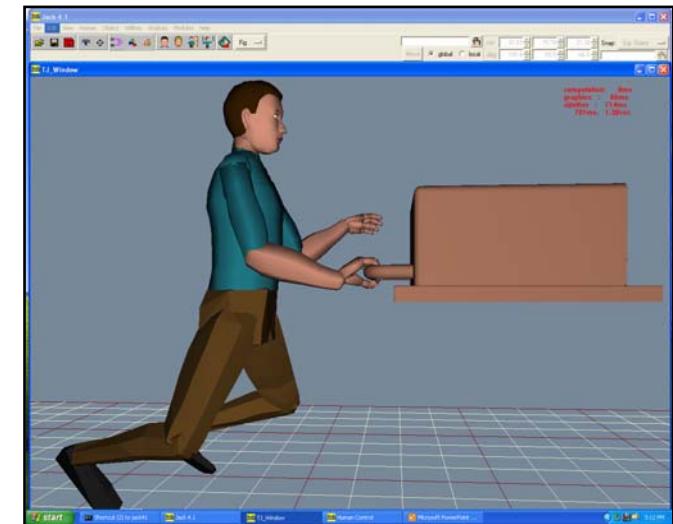
- Handle clearance of 1.875"

- Non-compliance:

- Current handle design has a clearance of 1.16"

- Waiver evaluation:

- Modification of crew procedure
    - Fit check performed to ensure operability by a full range of crew members

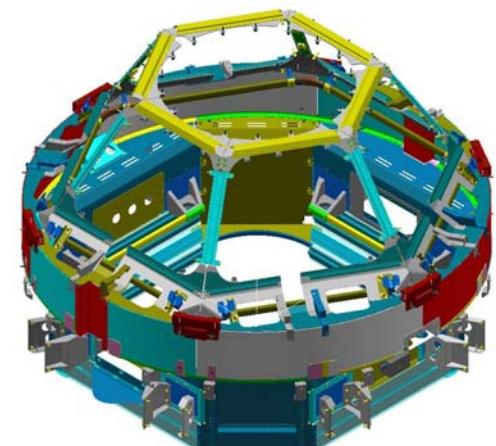


Representation of operation only—  
not anthropometrically accurate      Page 8



### Design

- Work with module and hardware developers to provide human factors design expertise
  - Provide human factors analysis for specific issues via the Space Human Factors Labs
  - Provide conceptual human-centered design support during the early phases of the project
  - Provide recommended design implementation (via Decal Catalog) for ISS labeling requirements to ensure readability and consistency
- 
- Example - Cupola:
    - Concern:
      - Placement of Robotic Work Station (RWS) inside the Cupola precluded view out the windows at the RWS
      - Design of the Cupola foot restraints did not fit 95th percentile male
      - Developer's assessment of anthropometry was inadequate; resulted in 3-D models and full scale mock-up evaluations
    - Beneficial design changes based on FCI guidance
      - Hardware design corrected early in design process by participating in full scale mock-up reviews and crew reviews
        - Would not have occurred if FCI did not review hardware design
      - Design modifications reviewed by the crew who were pleased with the improvements to the design



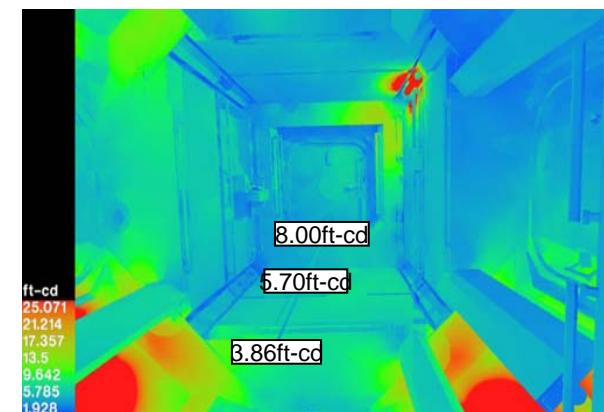


## Operations

- Address and pursue resolution for current on-board ISS human factors and habitability issues
  - Provide real-time support as needed to Mission Operations for human factors issues that arise during an ISS Increment
  - Collect post-flight data from Expedition crewmembers to determine and resolve issues

- **Example – Internal Lighting Assessment:**

- **Issue:**
    - Internal lights on ISS were failing at rates greater than expected
    - Spare lights were not available due manifest limitations associated with the grounding of the Shuttle
  - **Human Factors Concern:**
    - On-orbit lighting levels were falling below requirements and may pose a risk to the crew for safe, productive operations
    - No light meter is available onboard to verify lighting levels
  - **Issue Resolution:**
    - FCI provides analysis for current lighting levels to Mission Operations each time the lighting scenario changes (a light fails or spares are launched/installed)





# Examples of HSI ISS Lessons Learned

### Lack of Human-Centered Design



### Excessive Noise Levels



### Excessive On-Orbit Stowage



### Poor Usability of Procedures

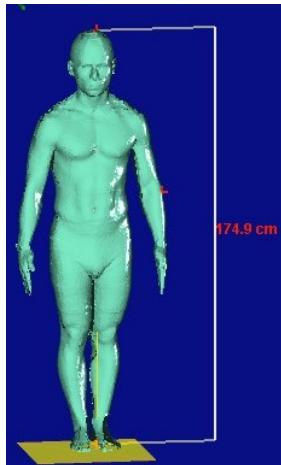




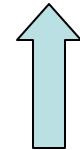
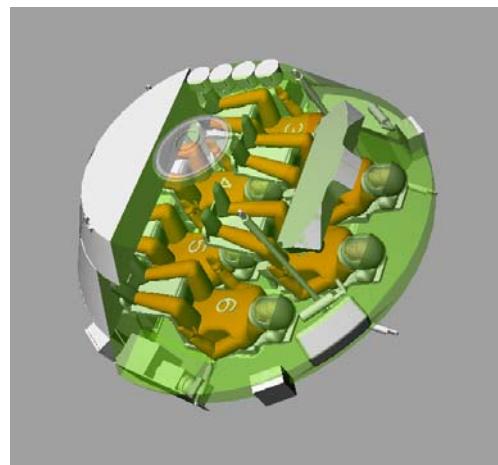
# CEV HE Support



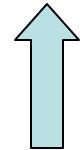
## Example of HSI Assessment for CEV—Net Habitable Volume:



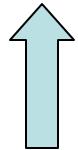
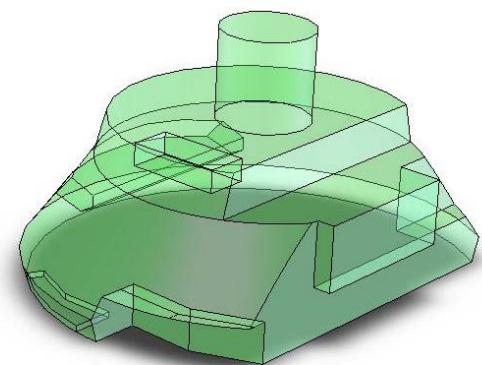
Anthropometric  
measurements



Graphical  
analysis



Mockup  
review



Verification  
criteria

- **Constellation**
  - HF SIG
  - EVA SIG
  - Supportability SIG
  - 
  - 
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# CEV HE Support

- **CEV**
- EVA Systems
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## Vehicle Integration

Crew Module

Service Module

Launch Abort System

Test & Verification

## CEV Cockpit WG

- Crew
- Engineering
- Operations
- Human Factors**

### Human Engineering Systems Integration Team

- Anthropometry / Biomechanics
- Usability / User Interfaces
- Crew / Stakeholder Evaluations
- Rapid Prototyping / Lo-fi Mockups
- Early Conceptual Design
- Human Modeling, Lighting Analysis
- HFE Requirements Development
- Design Review Support
- Test & Verification Support
- Liaison to Level 2 HF

- CEV Human Systems
- Operations
- FSW, Avionics, Cockpit
- Structures and Mechanisms
- Power & Propulsion
- Landing & Recovery
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- ECLSS/ATCS System
- Habitation Accommodations
- Suits / EVA / Crew Survival Equipment Interfaces System
- Radiation System
- Crew Health Interfaces
- Human Engineering**